Magnetic Petrology Database for Interpretation Satellite Magnetic Anomalies

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Summary. A Global Magnetic Petrology Database (MPDB) is now being compiled at NASA/Goddard Space Flight Center and consists of many thousands of records. The prototype database is located at http://core2.gsfc.nasa.gov/research/terr_mag/php/MPDB/frames.html. The purpose of this database is to provide the geomagnetic community with a comprehensive and user-friendly method of accessing magnetic petrology data via Internet for a more realistic interpretation of satellite (as well as aeromagnetic and ground) magnetic anomalies. MPDB is focused on lower crustal and upper mantle rocks and includes data on mantle xenoliths, serpentinized ultramafic rocks, granulites, iron quartzites and rocks from Archean-Proterozoic metamorphic sequences from all around the world. The definition of crustal magnetic anomalies is improving due to the mini-constellation of three satellites - Oersted, Champ, and SAC-C. Recent lithospheric field models (CM4, MF1, MF2) reveal magnetic anomalies with better resolution, for example in the areas of Iceland, Polar Urals Mountaines, and Anabar Shield where we have an excellent magnetic petrology records.

Key words: Database, Magnetic Petrology, Lithospheric

1 Introduction

One of the major outstanding problems in geophysics is the origin of magnetic anomalies observed by satellites in near Earth orbit. The wavelength of these anomalies suggests that they are crustal in origin. To construct sensible geophysical models of the likely sources of these anomalies comprehensive magnetic petrology information is required. Until now there has been no easily accessible central repository of such information. A Magnetic Petrology Database (MPDB) is now being compiled at NASA/Goddard Space Flight Center. The purpose of this database is to provide the geomagnetic community with a comprehensive and user-friendly method of accessing magnetic petrology data via Internet for more realistic interpretation of satellite magnetic anomalies. Magnetic Petrology data has been acquired from the NASA/Goddard Space Flight Center (Codes 691 and 921), United Institute of Physics of the Earth (Russia) and Institute of Geophysics (Ukraine) and from other worldwide sources. This data was accumulated over several decades and now consists of many thousands of records of data in our archives at GSFC. However most investigators do not have access to these data sets, which consisted, in part, of unpublished data. In addition, it is now recognized that magnetic petrology data is useless unless it is supported by the neces-

sary metadata: exact sample names and locations, tectonics settings, reference data, etc. There is a real need for a database that contains all the magnetic petrology data and supporting metadata in a form in which it can be accessed by the scientific community.

To understand the nature of long wavelength satellite magnetic anomalies it is necessary to have information about the magnetization in the lower crust and upper mantle. Therefore MPDB is focused on lower crustal and upper mantle rocks and includes data on mantle xenoliths, serpentinized ultramafic rocks, granulites, iron quartzites and rocks from Archean-Proterozoic metamorphic sequences from all around the world. The locations of available magnetic petrology datasets do not always coincide with the major satellite magnetic anomalies (except in the areas of Kursk and Kiruna Magnetic Anomalies). But such data for lower crustal and upper mantle rocks around the world is necessary to determine if magnetic rocks can or cannot be the sources of satellite and high altitude aeromagnetic and stratospheric magnetic data and for developing realistic global magnetic models. Moreover the data on crustal magnetic anomalies is improving due to mini-constellation of three satellites - Oersted, Champ, and SAC-C. Recent lithospheric magnetic models –CM3e (Sabaka et al., 2002), MF1 (Maus et al., 2001) reveal magnetic anomalies with better resolution (about 1 nT) for example in the areas of Iceland, Polar Urals Mountaines, Anabar Shield where we have an excellent magnetic petrology records. A substantial amount of data is coming from deep boreholes located in the area of the unique Kursk Magnetic Anomaly (Krivoy Rog BoreHole) and not far from Kiruna Magnetic Anomaly (Kola SuperDeep Borehole which recovered 12 km of continental crust).

2 Database Description

The development of Magnetic Petrology Database was initiated at Geodynamics Branch of NASA/GSFC in the end of 2001. A comprehensive magnetic petrology database includes much more than just the results of magnetic and petrological measurements. Supplementary data, usually called metadata (data about data) include sampling description, tectonic setting, geographical position of the sampling site, data of satellite magnetic measurements and reference metadata that give bibliographical information for the reference which reports the measured values. All of the information listed above represents multidimensional, related data that cannot be handled reasonably or efficiently in a two-dimensional flat file format database consisting of a number of separate spreadsheets. Searches for specific data would be complicated and inefficient because data need to be retrieved from each individual file separately. The optimal method for organization and delivery of such complex but related data is a relational database. Development of a relational database structure requires that all data that will be stored in the database are broken down into small logical units corresponding to the tables of the database. Primary keys need to be defined for each table, and relations among the tables need

to be established through foreign keys. The logical structure of a relational database is represented in the schema that illustrates tables, fields, and their relations. The schema of the Magnetic Petrology Database we are developing is shown in Figure 1.

The database consists of 6 interrelated tables. Logically, the central unit of the schema is the table SAMPLE_DESCRIPTION. Each sample for which magnetic petrology data are stored in the database is identified by a unique sample number, which serves as a foreign key throughout the database and links sample metadata in tables such as TECTONICS and REFERENCE to the measured data. All measured data are stored in two tables PETROPHYSICAL_DATA and PETROCHEMICAL_DATA. Metadata on satellite magnetic anomalies are planned to be included into database and stored in the tables Satellite_Magnetic_Anomaly.

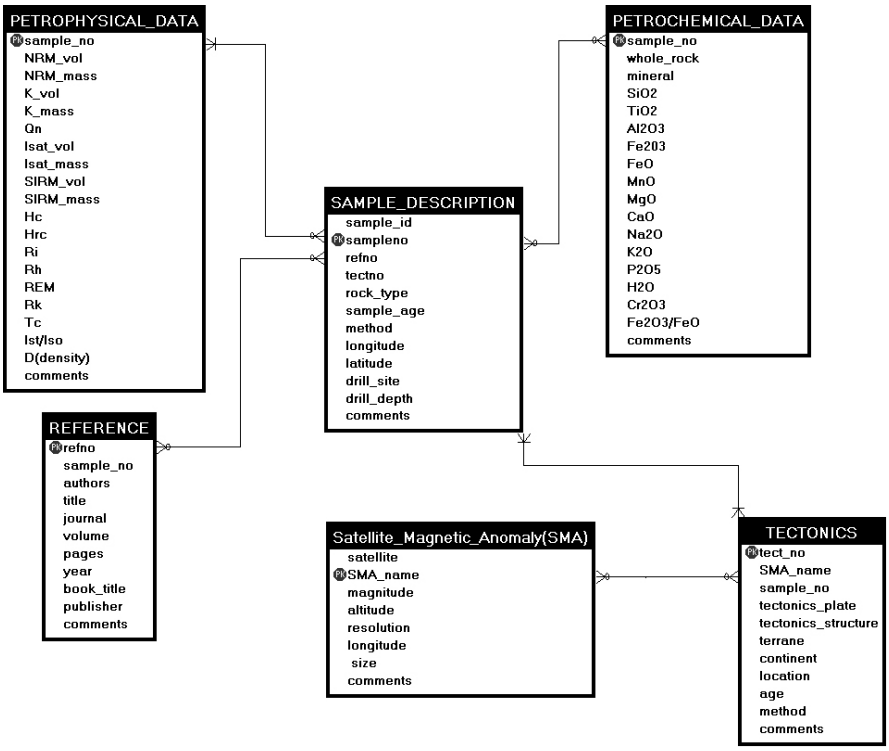

Fig. 1. The Schema of Magnetic Petrology Database

3. Database management and WEB presentation

The schema is the conceptual structure of a database. In order to build a working database version, the physical structure of the database needs to be created with a Relational Database Management System (RDBMS). The database then needs to be populated with data, and finally interfaces have to be developed to allow users to work with the data. We have successfully implemented the database in MySQL database management system under LINUX operation system. MPDB main page includes clickable map for 89 magnetic petrology data locations.

Data entry forms and applications are essential to facilitate the complex process of loading data into the tables while ensuring the uniqueness of primary keys, data integrity, and correct referencing of primary keys by foreign keys.

Submission data entry forms have been developed and can be found at: http://core2.gsfc.nasa.gov/research/terr_mag/php/MPDB/doc.html Access to the database for searching, viewing, and downloading data is best provided over the Internet in order to make it independent of computer platforms and locations. For the current applications, Web interfaces have been developed using PHP and CGI scripts. The interfaces allow the user to select samples and data by means of graphical tools such as frames. menus, scrollable lists, or buttons that generate and submit dynamic SQL statements to the database (see http://core2.gsfc.nasa.gov/research/terr_mag/php/MPDB/frames.html query database section)

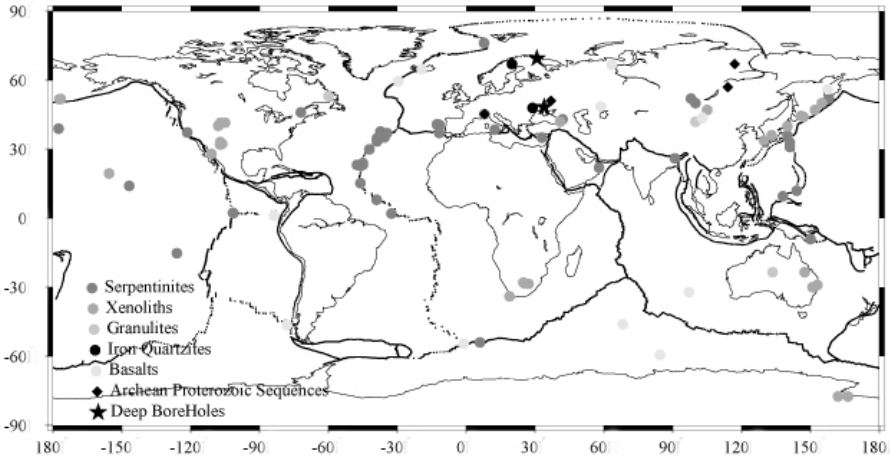

Fig. 2. Clickable Map for Magnetic Petrology Data Locations

4. Statistics

Submitted and included into database data are shown in Table 1.

ROCKS	TECTONIC STRUCTURE	# OF SAMPLES
Iron Quartzites (BIF)	Ukrainian Shield	10000
Sedimentary and BIF	Krivoy Rog BoreHole	303
Serpentinites, gabbro, sedimentary, volcanic	Baltic Shield Kola Deep BoreHole	400
Continental Serpentinites	worldwide	210
Oceanic Serpentinites	worldwide	460
Xenoliths	worldwide	2000
Basalts	Kamchatka	800
Ferrobasalts	Iceland	2000
Granulites	Urals Mountains	900
Archean Crustal Sections	worldwide	480

Table 1. Data included into Magnetic Petrology DataBase

5 Database applications

MPDB is a research oriented database and several database applications have been developed. (1) Magnetic data on Kola and Krivoy Rog BoreHoles were compared. Extremely high values of remanent magnetization (NRM), magnetic susceptibility (K) and Konigsberger ratio (Qn) are found at approximately the same depths of about 2000 m for both boreholes. Highly magnetic serpentinized peridotites and sedimentary rocks affected by sulfide mineralization were recovered at the Kola borehole for a depth interval of 1540-1940 m. The Krivoy Rog borehole recovered highly magnetic iron quartzites of Band Iron Formations at depths of 1853-2040 m. There is no obvious reason why high magnetizations should occur in two boreholes with different lithologies at the same depth. Magnetic surveys and surface sampling in the nearby Krivoy Rog and Kursk Magnetic Anomaly areas have revealed iron quartzites with high magnetization, similar to values given here. AF demagnetization tests suggest that hard and stable NRM component which is caused by hematite occurred in iron quartzites in different forms and grain sizes ranges. (2) Recent magnetic model (Maus et al., 2002) revealed quite intense positive lithospheric magnetic anomaly (> 5 nT) over Iceland. Magnetic data for about 2000 icelandic rocks were analyzed and we concluded that ferrobasalts (NRM aver =8.8 A/M and K aver= 0.054 SI) are most likely the source of satellite magnetic anomaly over Iceland. (3) Petrological data for basalts from Kamchatka (content of Fe and Ti oxides) were used to assign the level of basalts magnetiza-

tion. These values were utilized for interpretation the results of balloon geomagnetic survey in this area.

Status of development

- Magnetic Petrology Database (MPDB) contains data about rocks from all around the world (about 17,000 samples)
- MPDB is successfully designed, managed and presented on WEB.
- MPDB is a research oriented database and several database applications were developed.
- MPDB is expected to be the part of the system of existing geomagnetic and paleomagnetic databases under National Geophysical Data Center umbrella and will be used for more reasonable interpretation of high altitude magnetic survey products including satellite, stratospheric and aeromagnetic surveys and constructing more realistic magnetic models.

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